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THE MUSHROOM GROWERS'
ASSOCIATION

MGA BULLETIN

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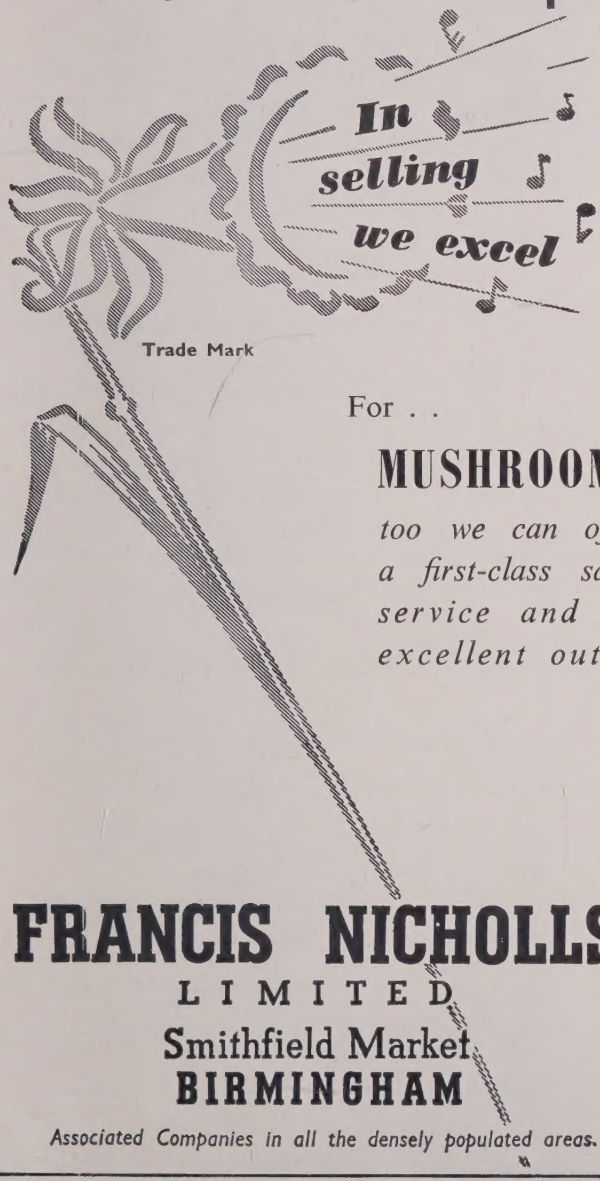

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NUMBER 133

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EDITORIAL

COVENT GARDEN

The Government's decision to go ahead with its plans for re-organising Covent Garden market and retaining it at its present site in the heart of London is, *in my opinion*, nothing short of stupendous folly.

Those of us who work in the great metropolis are only too well aware of the delays and frustration due to the traffic congestion and, in this congestion, the lorries to and from Covent Garden and the many vans and cars which daily stagger in and out of the market, play their full part.

Here at Covent Garden was presented a great opportunity which was literally forced by events on the authorities—a great opportunity to rid the centre of London of what for years has been a festering sore, a nuisance which has gone unchecked. Introducing the second reading of the Bill, the Minister of Agriculture said " Present conditions in and around the market are so bad that all agree that drastic reform is needed ". It is on the " drastic reform " that the Minister and I part company and I line myself up with, among others, Sir John Vaughan-Morgan (Reigate) who said that it was unfair that the Minister should have to defend an indefensible project, or Mr. Kenneth Robinson (St. Pancras North) who said " When I learned of the proposal to rebuild the market I thought the Government had taken leave of its senses ".

Everyone appreciates the sigh of relief with which the plans were received by the present market tenants, and of course all of us similarly placed would have fought tooth and nail to ensure a continuation of business, uninterrupted by a move to other quarters, and I certainly would not envisage a change of site without adequate protection for those, many of the MGA's friends amongst them, who would suffer ill by the move.

But this is 1961! This is a market which is being planned for centuries ahead, centuries throughout which it will, without doubt, come to be cursed as it is cursed to-day.

To my mind Covent Garden, with all its forty acres of frustration and restriction, should have been swept clean away and, in its place, modern well-planned flats should have arisen. The market should have been moved lock, stock and barrel to a completely new site to the North East or North West of London, north of the Circular Road where it would have been easily accessible to road traffic, and not too far removed from rail heads. The idea that something which is the centre of activity must necessarily be located in the geographical centre of things is sheer unadulterated nonsense. A Covent Garden market, removed a few miles from its present site would not have lost its present prime position.

What a great pity it is that such a splendid opportunity for example and action should be so wantonly cast aside. Of course the interests of those already in possession should be protected but so too should the interests of the general public and those of the producers as well.

WRA

ANNUAL LUNCHEON & A.G.M.

Lord Waldegrave as Guest of Honour

Lord Waldegrave, Parliamentary Secretary to the Ministry of Agriculture, has accepted an invitation to be Guest of Honour at the MGA's annual luncheon which takes place on Wednesday, 22nd March, at The Park Lane Hotel, Piccadilly (nearest Underground Station is Hyde Park Corner). As present arrangements stand the Chairman's Reception will commence at 11.30 a.m., with the Luncheon at 12.30 p.m. followed by the A.G.M. at 2 p.m. It is hoped that Lady Waldegrave will accompany her husband.

BULK OIL SCHEME

Additional Rebate

Members of the MGA taking part in the Bulk Oil Scheme whereby, through close co-operation, substantial rebates on the cost of fuel oil have been obtained, were informed on 1st January of a further and substantial increase in the rebates now being allowed. The MGA Scheme is being operated only by the Esso Petroleum Co. All enquiries regarding the scheme should be directed to the MGA Secretary.

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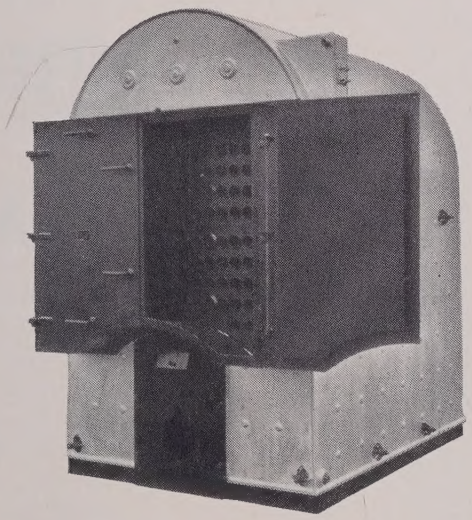

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TIMBER DURABILITY AND THE MUSHROOM GROWER

By **A. C. Oliver, M.Sc., A.I.W.Sc.**
(Timber Development Association Limited, Research Laboratories)

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Appendices—Preservatives suitable for Horticultural Use
Preservative Treated Plywoods
Durable Timbers for Horticultural Use.

1. Introduction

The Mushroom Grower will probably use timber and plywood in two main capacities, structurally and in the fabric of the mushroom house, and as a container and as bedboards and trays, when it may come into intimate contact with the mushroom compost and casing.

The desire of the grower to achieve a reasonable 'life' from timber products can be satisfied by either using a naturally durable timber or a timber adequately treated with a wood preservative which will not affect mushroom growth. To assist in making the best choice from the many materials and methods available, some of their salient properties are discussed below.

2. The Deterioration of Timber

Timber is a material which has a good resistance to chemical attack but like many materials of organic origin, it is subject to deterioration caused principally by fungi and insects.

Insect deterioration of timber is unlikely to be of importance to the mushroom grower. The furniture beetle which attacks softwoods and certain hardwoods, and the *Lyctus* (powder post) beetle which is confined to the sapwood of certain hardwoods (oak, ash, elm, etc.), are the two main types of beetle larvae that are likely to be encountered in decay-free timber, but under the high humidity conditions appertaining in a mushroom house, decay would cause much more rapid breakdown of the insect susceptible zones. Other types of beetle infestation may either occur as secondary infestations in decayed timber or as the semi-active remnant of beetle attack of the timber in the tree, log or during seasoning.

On the other hand decay is likely to be extremely rapid. The constant high temperature and humidity conditions which are maintained by the grower to encourage the growth of the mushrooms are

exactly those which most encourage timber decay. This is not altogether surprising when it is realised that the majority of timber decaying fungi are closely related to the cultivated mushroom.

Timber decay will occur under certain well defined conditions and it is avoided in normal building construction by keeping wood reasonably dry, or at least below 18% moisture content. As timber alters in moisture content in accordance with the temperature and relative humidity of the environmental atmosphere, it becomes evident that structural woodwork and the fabric inside a mushroom house under typical growing conditions, 55—70° F. and 88—90 RH, will have a moisture content of 22%, and probably very much higher during the cropping period when pathways and walls are regularly watered to increase the humidity. Trays, bedboards and other timber that will come into direct contact with soil and mushroom compost will have a much higher moisture content, probably in the range 50—100%. Similarly, timber in ground contact (e.g., as a post) will also be sufficiently wet for decay to occur. Under these conditions timber is liable to attack by many species of wood destroying fungi, *Poria xantha*, *P. vaillantii* and *Coniophora cerebella* probably being the most common on softwoods in horticultural buildings. Soft rot, caused by various species of micro fungi (*Fungi Imperfecti* and *Ascomycetes*), which is principally a surface softening decay, may also occur particularly on timber in contact with the soil. Percentages are expressed in relation to dry weight of wood.

Steam sterilization and fumigation procedures which may be carried out at the end of cropping are unlikely to affect the growth of wood decaying fungi, as the fumigants, although probably toxic to the fungi, would not penetrate throughout the affected wood. Similarly, the heat from sterilization would not penetrate very deeply into the timber, which, even under the damp conditions of a mushroom house, is a poor heat conductor. One hour's heating at 65° C. (150° F.) would be required to sterilize 1" thick planks.

From the foregoing, it is evident that some precautions must be taken to avoid the losses caused by timber decay. Two main courses of action are open; the use of naturally durable timber, or the use of preserved timber.

3. The Natural Durability of Timber

The sapwood or outer wood of many timber species is particularly susceptible both to insect and fungal attack, but conversely the heartwood of many timbers is very durable and resistant to decay. The durability of such timbers has been assessed in this country by the 'graveyard' test in which samples of timber each approximately 2 ft. long and 2" · 2" in section are set in the ground to a depth of 15" and the time taken for each sample to decay is noted. From the results of these trials it is possible to classify the heartwood of various species in order of durability or resistance to decay, and to compute an average life for 2" · 2" stakes in ground contact. The latest results of these trials show that the heartwood of Douglas fir and Larch (European and Japanese) have a life of 10-15 years, and Western red cedar has a life of 15 to 25 years.

These softwoods would all be suitable for mushroom house, mushroom tray and bedboard construction, particularly the Western red cedar, in view of its exceptional durability amongst softwoods.

Amongst the hardwoods, afrormosia, afzelia, greenheart, iroko, jarrah, opepe, and teak all have a ' life ' of over 25 years, and agba, sweet chestnut, idigbo, red meranti and European oak have a life of 15-25 years. Naturally durable species available in the form of plywood include makoré (over 25 years life), red meranti and agba (tola branca) 15-25 years life in ground contact. It should be stressed that plywood should be used in damp conditions only if bonded to WBP (Weather and Boil Proof) grade, as specified by British Standard 1455: 1956. Adhesives of this grade are completely resistant to moisture and will withstand many years exposure to the weather and damp conditions.

The life periods quoted for naturally durable timbers may not necessarily be repeated in the mushroom house. However, it can be stated that these ' life ' expectancies give a guide to the relative durability of different species, and the ' graveyard ' test exposes the timber samples to decay both of the wood destroying Basidiomycetes and soft rot types.

Drawbacks of using naturally durable timber are that all non-durable sapwood must be eliminated, that the degree of natural durability in different samples will vary, and that the ' life expectancy ' quoted above is an average figure for a number of samples of the species. The principal disadvantgage, however, may well be cost. Of the durable timbers quoted above, teak at about 60 - and afzelia and afrormosia at about 35/- a cubic foot are probably ruled out on cost, but iroko, greenheart and agba in the 23/- to 26/- range are more attractive, and jarrah, opepe, red meranti, idigbo, oak and sweet chestnut can all be obtained at less than 20/- per cubic foot.

Conventional European softwoods such as Scots Pine, Baltic redwood and whitewood will require preservation treatment and the cost of this treatment, added to the initial cost of the timber (about 10 - to 15 - a cubic foot), makes the cost of the naturally durable timber more attractive.

While discussing the use of naturally durable timber, the possiblity of corrosion by certain timbers of fixtures made from ferrous metals should be considered. Western red cedar, afrormosia, idigbo, oak and chestnut cause severe corrosion and care should be taken to fix these timbers with non ferrous materials.

4. Painting of Timber

It is often stated that timber can be preserved by painting. If by this we mean that timber can be permanently protected from biological deterioration, the statement is correct only so long as the paint film completely seals off the timber. End grain must be covered as adequately as side grain and the surface film must remain free from splits and cracks. As soon as the seal is broken, the way is clear for fungi to penetrate into the timber and cause decay, if it is susceptible, and if the moisture content is suitable.

In order to preserve perishable timber permanently it is necessary to use a timber preservative.

5. Types of Wood Preservatives and their Application

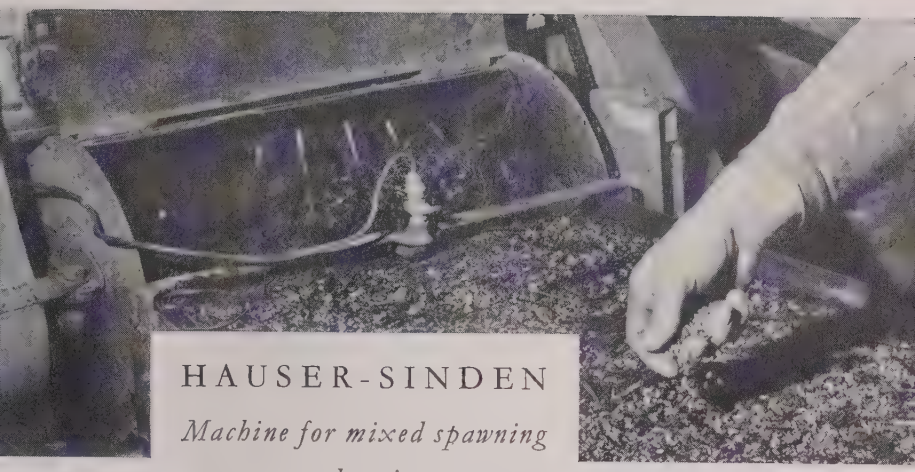
Timber preservatives are usually classified into three groups; the tar oils, which include creosote; waterborne, where toxic chemicals are applied to the timber in a water solution often by pressure vacuum impregnation; and organic solvent in which organic chemical poisons or their metallic derivatives are applied in an organic solvent, such as kerosene, white spirit or diesel oil, usually by brushing, dipping or spraying.

For pressure treatment of timber, special plant with a treatment cylinder which can withstand pressure of up to 200 lb./sq. in., and vacuums of 28 in. of mercury are required. An initial vacuum may precede the pressure period and a final vacuum is applied to remove excess preservative from the timber. This final vacuum is designed to provide maximum protection combined with economic preservative absorption. Waterborne and creosote type preservatives are applied in this manner and very deep penetration of preservatives into timber is usually obtained. The principal disadvantage of the method is that the treatment plants are usually only available near the larger towns and thus transport costs may loom large in the cost of treatment. When waterborne preservatives are used, the timber has to be redried after treatment.

The hot and cold tank treatment requires a simpler treating plant and yet still provides fairly good penetration. Provision must be made for applying heat to the preservative as the basis of the method is to heat the timber in the preservative for a few hours and then allow it to cool overnight. It is suitable for use with most waterborne and tar oil preservatives.

Most organic solvent and some waterborne preservatives are applied by steeping, dipping or brushing. Timber absorbs these surface applied preservatives very quickly initially and in a ten second dip treatment, half the absorption of a ten minute treatment will be achieved. Absorption of three brush coat applications are considered equivalent to a ten minute dip, whereas one brush coating roughly corresponds to a ten second treatment. Greater penetration and absorption are obtained with longer treatment times.

However, preservatives applied by brushing, spraying or dipping are unlikely to penetrate so deeply as those applied by hot and cold or pressure treatment, or to provide such long-lasting protection. To give an indication of the sort of durability that can be expected from representative preservatives of the main types, the results of graveyard tests in the U.S.A. indicate that whereas posts pressure treated with Celcure with an average retention of 0.52 lb./cu. ft. show no failure after ten years, copper naphthenate applied by one brush coat gave a ' life ' of about four years, and a three minute dip treatment gave a ' life ' of about five and a half years. It should be emphasised that these ' life expectancies ' should not be compared directly with those of British tests for natural resistance of timber as the hazard from decay is much greater in the U.S.A. tests and also that the test samples were exposed to termite attack.



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In all wood preservative methods, best results are obtained if the timber when treated is dry. Very poor absorption will be achieved if the timber is wet. The maximum amount of cutting, boring and shaping should be carried out prior to treatment. Any woodworking after treatment may expose untreated timber, especially if it is difficult to treat and of large dimension.

When attempting to assess the cost of preservation treatment it should be realised that the brush or dip applied preservative may cost between 7/6d. and 20/- per gallon or about 3.- per pound and the average recommended coverage is 200—400 sq. ft. per gallon (that is about 1/- per 30 sq. ft.) whereas the basic cost of pressure treatment is about 1/6d. per cubic foot. Treatments that are applied to provide a retention or recommended coverage per unit surface area are relatively less expensive used on large dimension timber, whereas treatments providing for an equivalent retention per volume of treated timber are cheaper used on wood with a large surface area (e.g., plywood).

6. The Phytotoxicity of Wood Preservatives

Having discussed briefly the types of wood preservative available, it is necessary to consider what effects these materials may have on the crop. Bearing in mind the close relationship between the mushroom fungus and the wood decaying fungus it is evident that we cannot expect to find a poison which will kill one without harming the other. What we can do is to ensure that the preservative in the wood is deposited in such a form that it can never come into contact with the mushroom crop.

Theoretically, preservative poisons or solvents might damage the spawn or the mushroom via the compost, the casing, the air, or by dissolving in water. It would be expected that the waterborne preservatives might affect the crop by dissolving in water and dripping into the crop, whereas the tar oil and organic solvent types might cause damage via the air by virtue of a volatile solvent or volatile toxic chemicals. Some laboratory trials were carried out during the last war at Rothampstead in which it was shown that whilst an organic solvent preservative containing copper naphthenate and two types of waterborne preservatives did not affect growth, creosote might give trouble and required further investigation.

After the war many new preservatives have appeared on the market and the latest information on the phytotoxic properties of these products has been obtained from horticultural trials. It seems reasonable to assume that these results can be applied in the mushroom house as the problems of preserving timber and the effects of preservatives on plants in general is common to both.

Work in America and Europe has shown that the vapour of creosote treated timber is injurious to plants. Trials in Finland on seven species of vegetables and flowering plants showed that this effect could be caused by timber 1½ years after creosote treatment, and American workers demonstrated this effect four years after treatment. It would seem, therefore, that the statements that creosote can be used as a horticultural preservative if the treated wood is allowed to weather for

some time after treatment and before being used in contact with plants, are refuted by these test results.

It has been claimed that creosote treatment for woodwork may assist in the control of *Fusarium* damping off disease of mushrooms by preventing ' carry over ' in wood from one cropping season to the next. There seems to be no particular reason why other wood preservatives should not prove just as toxic to this disease.

The trials in Finland showed that waterborne preservatives containing copper and arsenic in which a fixation of the poison in the wood has occurred, gave no trouble. Other products, in which fixation is not so complete, caused damage to the plants, as the chemicals could dissolve out into water which might subsequently come into contact with a sporophore or mushroom spawn. Practical experience and service records in this country indicate that this hazard can be avoided when precuations are taken to prevent ' contaminated ' water from coming into contact with the mushroom crop. Such unfixed waterborne preservatives intended for application by brushing, dipping or spraying include those using copper, metallic derivatives of pentachlorphenol and organic mercurials as toxic chemicals. 5% copper sulphate solution has also been suggested. It can be easily made up by the user and it has been shown that it does not cause any ill effects.

Trials in Finland showed that the vapour of organic solvent preservatives containing pentachlorphenol caused considerable damage to plants and that this effect was evident even two and a half years after treatment. The use of pentachlorphenol in horticulture is not, therefore, recommended. The same cannot be said for the metallic and organic derivatives of p.c.p. which have a much reduced volatility. Such derivatives are used for preservation of horticultural timbers apparently without causing damage to plants.

The trials did also indicate that organic solvents with copper naphthenate as the toxic compound had no effect at all on growing plants. The extensive and continued use of copper naphthenate as a horticultural timber preservative was, therefore, supported. Similarly, the use of white spirit as a solvent was shown not to affect the plants.

Claims have been made by various manufacturers that certain wood preservatives have proved very effective in preventing mould growth on timber and also in assisting in the control of various insect pests of the mushroom. As with *Fusarium* control by creosote, it seems reasonable to assume that most wood preservatives are equally effective in this pest and mould control.

From the preceding paragraphs it can be seen that whilst creosote and pentachlorphenol should not be used as wood preservatives for horticultural use, organic solvent preservatives based on copper naphthenate and waterborne preservatives that have a high degree of fixation proved satisfactory in various trials. Derivatives of pentachlorphenol and certain unfixed waterborne preservatives have proved themselves as suitable in practice provided precautions are taken to prevent ' contaminated ' water dripping onto the crop, and can also be recommended.

The manufacturers and the names of proprietary products of these types are shown as an appendix to this paper.

It should be realised that the long term durability of unfixed waterborne and organic solvent preservatives will not be as great as the fixed waterborne preservatives, periodic retreatment being necessary in order to prevent decay. The pressure treatment, however, can be considered as a once and for all treatment.

7. The Permeability of Timber to Wood Preservatives

The permeability of timber to wood preservatives varies considerably between different species. Generally the sapwood which is very prone to decay is very permeable and can be adequately protected by preservatives. Heartwood varies in permeability and some softwoods are very difficult to treat. Amongst the softwoods, Douglas fir, Western hemlock and ' whitewood ' are all difficult to treat, and from this point of view should be avoided in the mushroom house.

Many non-durable hardwoods are difficult to treat but their use by the grower is unlikely. He will normally prefer the naturally durable species. The greater cost of hardwoods would probably make their preservative treatment costly and, therefore, uneconomic.

8. The preservative treatment of Plywood

Plywood preservation can be accomplished by either gluing preservative treated veneers or by treating the finished product. The former method, whilst giving a very thorough treatment, is a costly product. When exterior (WBP) plywood is pressure treated after manufacture the penetration may not be so complete but the cost will be lower and more competitive with the plywood manufactured from naturally durable veneers.

Plywood can, of course, be treated on the site or *in situ* by using preservatives suitable for steep, dip or brush application.

9. Conclusion

It can be seen from the preceding discussion that many answers are now available for the problem of timber decay, both in the fabric and structure of the mushroom house and also in the bedboards, trays, etc. The ultimate choice between the use of naturally durable timber and pressure and non-pressure preservatives will be based on convenience and cost.

A classified list of wood preservatives and pretreated plywoods suitable for use by the mushroom grower is attached as an appendix, together with the names of the manufacturers from whom further information about their products can be obtained.

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APPENDIX

Preservatives Suitable for Horticultural Use

(Taken in part from 'Timber Preservation' booklet)

1. Waterborne Preservatives

	TRADE NAME	MANUFACTURER
(A) Applied by pressure methods deposited in a highly fixed state in the timber	Tanalith C (copper-chrome arsenate)	Hicksons Timber Impregnation Co. (G.B.) Ltd., Castleford, Yorks.
	Celcure (copper-chrome)	Celcure Limited, Aldwych House, Aldwych, London, W.C.2.
(B) Applied by non-pressure methods and deposited in a fixed state	Horticel (copper-chrome)	Celcure Limited, Aldwych House, Aldwych, London, W.C.2.
(C) Non-fixed preservatives	Santobrite (Sodium penta-chlorphenate)	Monsanto Chemicals Ltd., Monsanto House, 10-18 Victoria Street, S.W.1.
	Phenyl Mercury Fixtan (Copper quinolinolate)	Ward Blenkinsop & Co. Ltd., York House, 37 Queen Square, London, W.C.1.
	5% Copper Sulphate	

2. Organic Solvent Preservatives

(A) Applied by non-pressure methods	Green Cuprinol (Copper naphthenate)	Cuprinol Ltd., Terminal House, Grosvenor Gardens, London, S.W.1.
	Solignum U.D.K. (Copper naphthenate)	Solignum Ltd., 30 Norfolk Street, London, W.C.2.
	Mystox L.P.L. (Pentachlorphenol derivative)	Catomance Ltd., 94 Bridge Road East, Welwyn Garden City, Herts.

PRESERVATIVE TREATED PLYWOODS

Preservative Treatment

CELPLY	Celcure	Thames Plywood Works Ltd., Harts Lane, Barking, Essex.
TANAPLY	Tanalith C.	Tyne Plywood Works Ltd., Willington Quay, Wallsend-on-Tyne, Northumberland.

DURABLE TIMBERS FOR HORTICULTURAL USE

Softwoods

Western red cedar.

Hardwoods

Afrormosia, Afzelia, Agba, Sweet Chestnut, Greenheart, Idigbó, Iroko, Jarrah, Red Meranti, Oak, Opepe and Teak.

Plywoods (Bonded to W.B.P.)

Agba (Tola blanca), Red Meranti and Makoré.

You can make better compost more quickly and reliably-with

ADCO 'M'

SPECIAL MUSHROOM COMPOST ACTIVATOR GIVES HIGHER FERMENTATION TEMPERATURES, AND A FIRST CLASS COMPOST THAT ASSISTS THE SPAWN RUN

MANY ADVANTAGES are gained by using Adco "M" as an activator in composting. Chief among them is the higher temperature attained both in the compost heap and in the beds during the peak heating process. Look at the results that follow from these higher temperatures.

First of all, fermentation goes ahead at a faster rate. Composting takes less time and the finished product is ready earlier.

Secondly, you have greater assurance that your crop will be free of pests and disease. The higher temperature either kills off the pests inside the heap or drives them to the surface, where they can be dealt with by insecticides. High temperatures during fermentation are particularly vital in preventing disease such as Vert-de-gris, of which there is special danger when composting during the winter months.

More nourishment

If you use Racing Stable manure, or other manure in which excess straw is present, the use of Adco "M" is strongly advised. The fermentation of this type of manure takes place more rapidly and effectively when Adco "M" is added. You get a more thorough breakdown of the strawy material, which then becomes available as food for the growing spawn. So your compost provides more nourishment for the mushrooms, and you get a bigger crop.

Better spawn run

Adco "M" produces a good quality compost of even texture. It provides an ideal medium for spawn run and helps to avoid greasy conditions, lack of aeration, and over wet compost – all of which delay mycelium growth. The spawn is able to make more rapid use of the food provided. It establishes itself more quickly and this is again a great help in preventing diseases and weed fungi. The faster the spawn grows and fills the compost the less likelihood is there of disease and weed fungi becoming serious competitors. A quick spawn growth also gives a quicker ultimate production.

You can have freedom from uncertainty in the composting process – by using Adco "M". It will pay you hands down. Adco "M" is specially formulated as a result of years of experiment, for the specific purpose of making mushroom compost. It can be used for composting with straw alone, if you wish. Or it can be used to compensate for variations in the quality and texture of your manure supply. Adco "M" provides the way to better mushroom compost every time.

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CHANGES AT WRINGTON VALE NURSERIES

55% Take-Over by Trading Group for £110,000

It was announced in the *Financial Times* on 13th December, that a Birmingham Issuing House had acquired control of Wrington Vale Nurseries, owned by Mr. Graham Griffiths, Vice-Chairman of the MGA.

The announcement read:—

Neville Developments, the Birmingham issuing house and trading group, has acquired for £110,000 cash all the issued 55,000 7½ per cent. Cumulative Redeemable Preference £1 shares and 55,000 of the total issued 100,000 Ordinary £1 shares in **Wrington Vale Nurseries.**

Wrington is a new company formed to acquire and carry on the business of mushroom growers and nurserymen formerly carried on by Mr. G. C. J. Griffiths, under the Wrington name, at Congresbury, Somerset. Mr. Griffiths has been appointed managing director of the new company.

GERMAN GROWERS CONFER

The Annual Conference of the German Mushroom Growers' Association was held at Neustadt-Weinstrasse, on 22nd and 23rd October, 1960, and was presided over by the President, Herr Hullen, who, ably assisted by the untiring efforts of Herr Hoos of Neustadt, was responsible for its outstanding success.

German growers are no less enthusiastic about mushrooms than their English counterparts and the topic of conversation never varied.

Over 140 delegates attended the Conference and many scientists well known to a number of English growers were present. Professor von Sengbusch, Herr Huhnke, Fräulein Fritsche and Fräulein Eger from the Max Planck-Institute at Hamburg gave papers on the work being carried out at their research station, including the paper on active mycelium given at the MGA Conference at Weston-Super-Mare. Fräulein Eger's paper dealing with the fructification of mycelium opened up a new approach to the matter and it is hoped that this excellent paper will be given in this country during the coming year.

Dr. Rempe's paper dealt with the contamination of mains water due to detergents in the rivers adjoining the wells. In this most interesting paper Dr. Rempe was understood to say that nematodes can be carried to the beds by mains water.

Professor Dr. Riethus from Berlin told of the work being carried out at the Institute and Dr. Kohn gave a paper dealing with the European Market. Papers by Dr. Botticher and Dr. Seidel and the showing of the " Esso " film of mushroom growing as practised at Oxted, Surrey, completed a most interesting programme.

Other scientists attending included C. Riber Rasmussen and Dr. H. J. Tschierpe, both of whom contributed to the discussions following the papers.

Three of the major points of the conference were:—

(i) Reports of the scientific work being carried out in Germany.

(ii) The problem of the European Market and the possibilities of obtaining understanding and agreement between growers in Europe in marketing, grading, canning, etc.

(iii) The difficulties facing the European growers where a market only exists for the small tight button. Possible ways of educating the retailers to sell and the housewife to buy various grades as in England. (An active publicity committee supported by a well-founded publicity fund was suggested.)

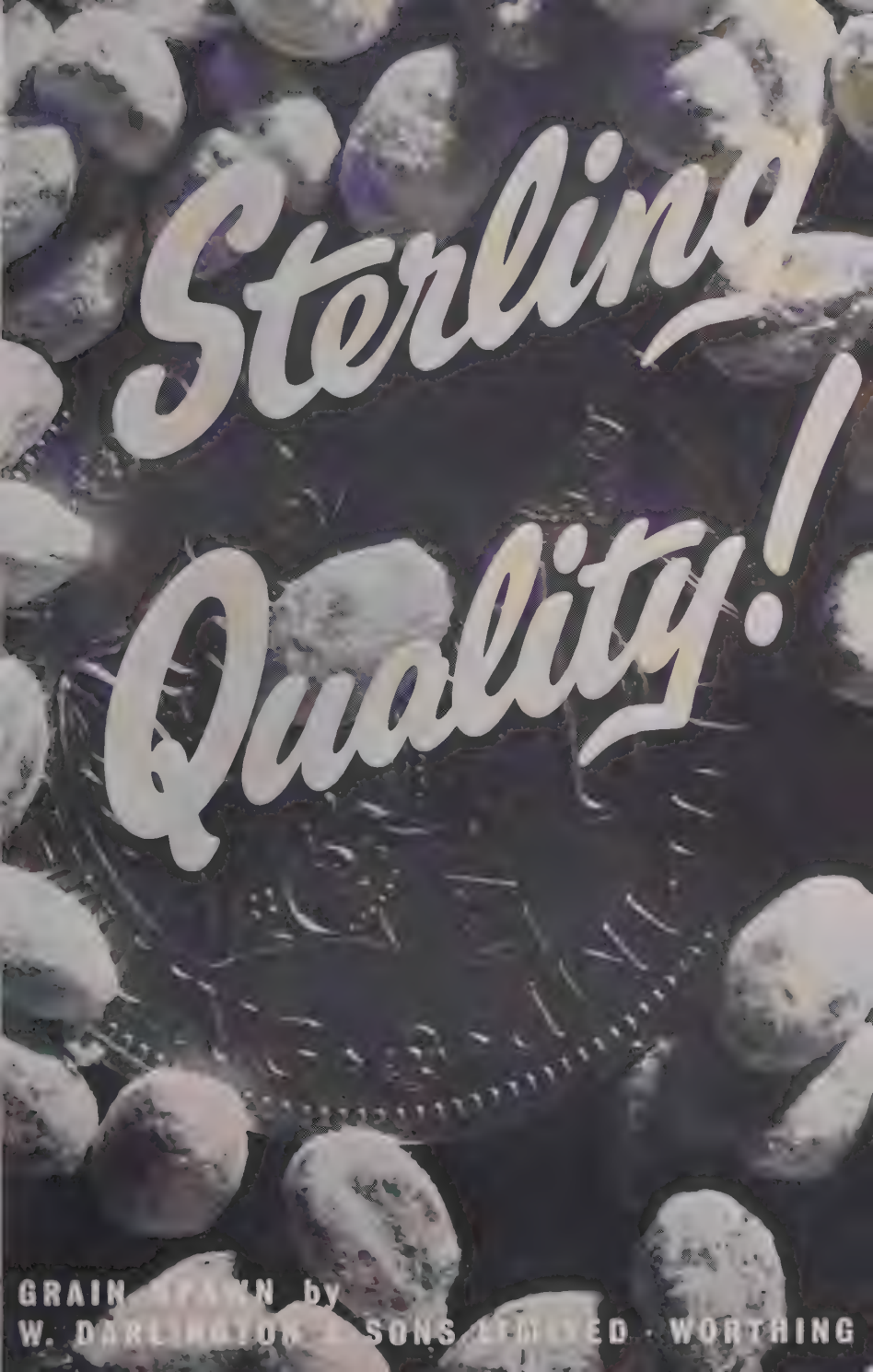
The social side of the conference was taken care of by holding a dance and cabaret on the Saturday and confirmed the point that mushroom growers do really enjoy themselves on these occasions.

Our MGA is held in very high esteem by the German growers and the "Bulletin" is greatly appreciated. (GWB)

OBITUARY—Mr. T. Ainslie Robertson

The death has occurred at Amberley, Sussex, of Mr. Thomas Ainslie Robertson aged 70, the first Chairman of the Glasshouse Crops Research Institute at Littlehampton. In 1937, he became the first Managing Director of Plant Protection Ltd., a subsidiary of I.C.I., and was later chairman of that company.

In a letter to Fred. C. Atkins, written last October, the late Mr. Robertson said "I greatly enjoyed my contacts with the mushroom growers and I am happy to think that research into the problems of the industry is now on a sound basis." This was in reply to a letter from F.C.A. written on behalf of the industry and the MGA Research Committee.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NEW WAGE RATES

New wage rates, fixed by the Agricultural Wages Board (England & Wales) came into force on 2nd January. The rates given herewith do not include Cambridge and Yorkshire or the Holland Area of Lincolnshire. The MGA Secretary will be pleased to supply information regarding these areas, on request. The rates quoted are the minimum and relate to a full time week of 46 hours, unless otherwise stated.

Weekly:—

Male Workers Years of age	Per week s.	d.	*Female Workers* Years of age	Per week s.	d.
20 and over	169	0	21 and over	128	6
19 and under 20 ..	143	6	18 and under 21 ..	118	6
18 „ „ 19 ..	122	6	17 „ „ 18 ..	99	6
17 „ „ 18 ..	105	0	16 „ „ 17 ..	83	0
16 „ „ 17 ..	89	6	15 „ „ 16 ..	69	6
15 „ „ 16 ..	77	6			

Part Time: –

Male Workers Years of age	Per hour s.	d.	*Female Workers* Years of age	Per hour s.	d.
20 and over	3	8	21 and over	2	10
19 and under 20 ..	3	2	18 and under 21 ..	2	7
18 „ „ 19 ..	2	8	17 „ „ 18 ..	2	2
17 „ „ 18 ..	2	3	16 „ „ 17 ..	1	10
16 „ „ 17 ..	1	11	15 „ „ 16 ..	1	6
15 „ „ 16 ..	1	8	14 „ „ 15 ..	1	3
14 „ „ 15 ..	1	6	13 „ „ 14 ..	1	1
13 „ „ 14 ..	1	3			

Overtime:—

Male Workers Years of age	Per hour s.	d.	*Female Workers* Years of age	Per hour s.	d.
20 and over	5	6	21 and over	4	2
19 and under 20 ..	4	8	18 and under 21 ..	3	10
18 „ „ 19 ..	4	0	17 „ „ 18 ..	3	3
17 „ „ 18 ..	3	5	16 „ „ 17 ..	2	8
16 „ „ 17 ..	2	11	15 „ „ 16 ..	2	3
15 „ „ 16 ..	2	6			

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1960 IN RETROSPECT

Nineteen-and-Sixty, crystal clear,
Heralded MGA's fifteenth year;
O'er its threshold 'midst winter's wind
Super-spawned beds readily pinned,
And more pinheads were in the pink
By reappearing in Yorkshire ink;
And still more ink our printers use,
As, inducing mycelial strands to fuse,
Dr. Tschierpe (whom much we owe to)
Writes more and more on CO_2
Seven past-Chairmen, smart as grooms,
Were honoured guests in Connaught Rooms
To dine, to wine, reports review
At that familiar rendezvous.
Then just before mid-summer's day
The wedding bells were ringing gay,
And many folks that mushrooms grow
Were wishing well our P.R.O.
Did Autumn meetings ever savour
Of so much international flavour?
Or holiday-makers ever get
The sun we had in Somerset?
Or England on any former occasion
Be stormed by such an Irish invasion?
Or silver cups from their parish flee
As seven out of nine crossed the Irish sea?
And so, in reading this epistle
We find within MGA's crystal
A live current,—what could be apter
For Nineteen Sixty, our fifteenth ' chapter '?

F.P. (BELFAST).

MUSHROOM SCIENCE 4 READY

Mushroom Science IV, the proceedings of the 4th International Mushroom Congress has now been published in one complete volume of 572 pages, and copies may be had from The Secretary, the Mushroom Growers' Association, Agriculture House, Knightsbridge, London, S.W.1, at £3 - 12 - 6 ($10·25) per copy, including postage, or direct from The International Commission Mushroom Science, Champignon-Laboratoriet, Rolighedsvej 23, Copenhagen V, Denmark for Danish Kroner 70.00 plus postage.

Publication of these proceedings has been somewhat delayed and the many difficulties encountered included the voluntary correction and editing of the many papers in different languages. The amount of the available copy, filling 572 pages, caused the printing costs to exceed the original estimate.

Mushroom Science IV contains all the lectures in full, as presented at the Congress, including English, French and German summaries in every applicable case. Included also are the names and addresses of those participating and reports of the official speeches.

STUDIES ON THE INFLUENCE OF CARBON DIOXIDE ON THE CULTIVATED MUSHROOM

By **Dr. H. J. Tschierpe**

Institut für Gemüsebau der Technischen Universität Berlin
Direktor Prof. Dr. H. Riethus

(*The original paper was published in "Die Gartenbauwissenschaft 24, 1, 18-75, 1959*)

F. Discussion and conclusions

Consideration of the experimental results described here shows the importance of carbon dioxide for the growth and for the life cycle of the cultivated mushroom. The ventilation of the houses used for mushroom cultivation is undoubtedly necessary in order to get rid of the carbon dioxide that is produced in the compost, by the mycelium and by the sporophores. The influence of carbon dioxide can be observed in all stages of the life cycle.

During the " spawn run " high CO_2 concentrations cause a growth inhibition, which could lead – in extreme cases—to a complete stoppage of growth. In the experiments described 2 per cent CO_2 caused a significant retardation of growth, 32 per cent caused almost complete stoppage. The growth inhibition is to a great extent independent of the oxygen content of the air. In this respect the cultivated mushroom has the same behaviour as other aerobic fungi. The straight-line in a log-log scale is typical for fungi growing in the upper parts of the soil horizon. No exact observations or experiments on the appearance of mycelium of wild growing *Agaricus* (*Psalliota*)—species in the soil horizon are known to the author. According to private communications with mycologists (Bickerich, Hennig, 1958) the mycelium of these species is restricted to the upper 4 inches of the soil. The straight line observed confirms these statements.

In practice the growth inhibiting influence of carbon dioxide means a danger during the spawn running period, in which—especially in the tray system –the trays after spawning often stand close together in unventilated spawn running rooms. Here might occur unnoticed but significant growth inhibitions which can lengthen the spawn running period and thereby raise the cost of production. Provided that the relative humidity and the temperature can be kept at the optimum some ventilation during spawn running is to be recommended, because as a result the spawn growth is faster and thicker and the beds can be cased earlier. It seems not impossible that the reduction of the production capacity, observed by **Mader** (1943) on trays which stand during the spawn run under closed room conditions, is a result of the inhibited mycelial growth.

According to our CO_2 determinations the application of casing soil is connected with a CO_2 increase in the compost. If after casing the rooms are not ventilated, the casing soil does not initiate the fruit-body formation; instead the mycelium grows through the casing and spreads on the surface.

In our experiments it was possible to cause the superficial growth of mycelium by ventilating with an airstream, artificially enriched with 0.5 and 1.0 per cent carbon dioxide. The following theory is advanced to account for the function of the casing soil and for the cause of fructification of the cultivated mushroom: A CO_2 partial pressure gradient is necessary for fructification of the cultivated mushroom. The fruitbodies are formed in the region where the high CO_2 concentration of the bed meets the low concentration above it. The region of the gradient is in the casing soil. For fruitbody initiation the CO_2 content of the air in or directly above the casing soil must be less than 0.5 volume per cent.

A CO_2 concentration difference between 0.3 to 0.8 volume per cent in the compost and 0.04 to 0.08 per cent in the room air was measured during the cropping period under commercial conditions, i.e., the CO_2 content of the compost air was in the average 5 to 10 times higher than in the room air. It could be shown that in the absence of a CO_2-partial pressure gradient no fruitbody formation takes place. In culture boxes ventilated with CO_2-free air normal shaped sporophores always developed. In contradistinction to the boxes placed in unmoved room air (CO_2 content 0.04 per cent) the fruitbodies were formed deeper in the soil, whilst in the unmoved room air pinhead formation always took place near or upon the surface of the casing layer. By the air movement directly over the casing layer the region of the partial pressure gradient was shifted deeper into the soil, whilst in the unmoved room-air it was nearly on the surface.

Under commercial conditions the pressure gradient is caused by the ventilation after casing. If the ventilation starts too late or if it is too weak stroma occurs on the surface of the bed. Under these conditions empirical working practice recommends heavy watering and increased ventilation. Both measures increase the CO_2 partial pressure gradient between compost and room air and so provide the basis for fructification.

A casing soil mixture of chalk and peat is used more and more in modern mushroom growing. A study of the possible effect of chalk as a CO_2 absorbent in this case would be desirable.

In order to create optimum conditions for fruitbody formation it seems useful to ventilate shortly after casing. A uniform moisture content of the casing soil during that time is necessary so that the mycelium can grow into the casing and can reach the region of the CO_2 partial pressure gradient which initiates fructification. If the mushroom houses were not ventilated with fresh air but the air was only recirculated in an airheating system, excessive CO_2 concentrations would easily be reached and the fruitbody formation might be decreased or even prevented by the absence of a CO_2-concentration gradient.

How far these conditions are also valid for other hymenomycetes is unknown. It would be of great interest to study from this point of view the development of the fruitbodies of other hymenomycetes which do not only depend on rainfall. It is well-known that a lot of wood fungi especially occur after rain. After a rainfall, however, high CO_2-concentrations also occur in humus rich soils. It therefore seems possible

that here also the CO_2 partial pressure gradient between the soil and the atmosphere has an effect on fructification. The upper layer of the soil with its air-space decreased by water would in this case operate as a diffusion inhibiting " casing ".

During their rapid growth growing sporophores produce large amounts of carbon dioxide. The fruitbody reacts to high CO_2 concentrations with an increased growth of the stipe and—at the same time—inhibition of the cap growth. It seems to us that there exists here a mechanism which guarantees the distribution of the spores and which is governed by the CO_2 content of the air surrounding the sporophores. According to **Magnus** the purpose of the normal process of development lies " without any doubt in the suitable distribution of the spores ". In the mushroom the purpose of this whole plan can come to full expression only if, after a complicated formation process, the last stage of maturity is reached and the cap has opened. All the impulses and complex correlated events, all the inner conditions of the development do only serve this purpose (**Magnus** 1906, p. 155). Also **Ulbrich** (1926) considers the sporophores of the hymenomycetes as "formations which have to develop the reproductive organs and to place them so that the species-maintaining spores are brought into a position as advantageous as possible for their distribution."

The spores are distributed by moving air. Moving air is poor in carbon dioxide under natural conditions. High CO_2 concentrations are —always natural conditions provided—a sign of stagnating air. If the growing sporophore, which only forms at low CO_2 concentrations, grows into an air with a high CO_2 content it reacts with an increased stipe growth by which the hymenium-bearing cap is lifted into moving (= CO_2 poor) air. Only here will the cap open and sporulate. If the cap, in spite of the stipe elongation does not reach an atmosphere with a low CO_2 content, the fruitbody dies without the cap opening, i.e., without sporulation (see experiment II D). Every mushroom grower has probably observed an elongation of the stipe of mushrooms which grow in large clusters, as they often do in the first flushes. The fruitbodies in the centre of such clusters have long stalks, whilst the stipe of the mushrooms at the outer margin is normal. There exists a microclimate in such clusters which is separate from the micro-climate in the house by the caps. The metabolic carbon dioxide given off by the growing sporophore and from the bed, accumulates under the caps around the stipes, stimulates the elongation of the stipe and so the caps are lifted into a " moving " atmosphere, guaranteeing the distribution of the spores. This phenomenon, characterised by **Stoller** (1945) as " overstimulation ", is without doubt a mere CO_2 effect. CO_2 determinations under such clusters not described in detail here, showed significantly higher CO_2 concentrations than on other plots without growing sporophores.

The ratio of cap : stipe weight of normal sporulating fruitbodies is about 2 : 1. If sporophores develop under high CO_2-concentrations the total weight of the mushroom is reduced. The ratio in air with 0.3 volume per cent CO_2 was about 1 : 1 to 1 : 3; at 4.0 to 5.0 volume per cent CO_2, 1 : 5 to 1 : 10. For each CO_2 concentration there seems to

exist a characteristic ratio. The determination of this ratio is only possible in large " field " experiments. It depends especially on the size of the sporophore at the beginning of the treatment. The described ratios are valid for a size of 0.7 to 1.2 cm. cap diameter at the beginning. The larger the sporophore at the beginning the less striking is the morphogenic CO_2 influence. On the other hand high CO_2 concentrations have very little or no influence on tiny pinheads. These stop growing and die off. But if the sporophores have the size mentioned at the beginning of the treatment they grow up to a concentration of 10 volume per cent CO_2. At concentrations of more than 11 per cent the mushrooms die. Spores were not formed in the range from 10 down to 1.5 per cent CO_2. At concentrations lower than 1.5 per cent in some cases the caps opened and spores were formed. A uniform normal sporulation occurred only at CO_2 concentrations lower than 0.5 per cent. Stipe elongation was observed down to a concentration of 0.3 per cent. Normal shaped fruitbodies developed only in air with less than 0.3 volume per cent CO_2. The " border " is about between 0.1 and 0.15 volume per cent CO_2.

During the growth of the fruitbodies the function of the mycelium is mainly to take up nutrients and water and to transport them to the sporophores. Therefore the metabolism of the mycelium is low. Large amounts of CO_2 are, however, given off by the fast growing fruitbodies. The CO_2 concentration in the compost during the growth of a flush was about 0.25 per cent. After picking a complete flush a distinct increase of the CO_2 concentration was observed. CO_2 concentrations up to 3.4 per cent occurred after picking. The following cause of this phenomenon is suggested : By picking the still fully active and growing fruitbody an intensively respiring part, an "exhaust pipe", is cut off from the mycelium. The main metabolism is now shifted to the mycelium which is filled with water and nutrients for the fruitbodies. That could explain the high CO_2 concentrations. At the same time that causes a high CO_2 partial pressure gradient, as after casing the beds. It is supposed that this causes the initiation of the next flush. That means that under commercial conditions one must use forced ventilation during the growth of the fruitbodies, to prevent the development of long stalked mushrooms with tiny caps and low weight. But ventilation has also to continue after picking in order to get rid of the high CO_2 concentrations in the compost and in order to obtain a normal partial pressure gradient. In unventilated rooms there is an increased diffusion of CO_2 from the bed into the room air (caused by the large concentration difference), which can lead to too high CO_2 concentrations in the room air. These can prevent the fruitbody initiation and cause vegetative growth on the casing.

How far the reduced yields during hot summers are caused by too high CO_2 concentrations in the cropping rooms could not be determined. The fact that at high temperatures increased CO_2 formation takes place and that those growers who use forced ventilation at high outside temperatures do not have reduced yields, leads us to suppose, that there exists a direct connection between high outside temperatures and yield-reducing unsuitable CO_2 conditions.

Summary

1. Carbon dioxide inhibits the growth of mushroom mycelium. The inhibition is to a great extent independent of the partial pressure of oxygen. There was no significant difference in growth in gas mixtures composed of 70 volume per cent nitrogen and 30 volume per cent oxygen from those containing 95 volume per cent nitrogen and 5 per cent oxygen. Independently of the oxygen content, 2 volume per cent carbon dioxide caused a significant retardation of growth and with more than 32 volume per cent CO_2 there was no growth at all.
2. The CO_2 content of the air in the compost decreased during the development of the sporophores under commercial farm conditions just as in the small culture boxes used for laboratory experiments. Less than 0.3 volume per cent was seldom measured. The carbon dioxide content of the air in the compost increased with rising temperatures, after application of the casing and immediately after complete picking of a flush. A connection is suggested between these increases and the phenomenon of flushes.
3. Carbon dioxide has a morphological and physiological influence on developing mushroom sporophores.
   Concentrations of more than 11 volume per cent caused the death of the sporophores without changing their form. CO_2 concentrations between 1.5 and 10.0 per cent caused a strong elongation of the stipe and a thickening of the basal region and prevented the normal development of the cap and sporulation. Normal sporulation was observed within a range of 1.5 to 0.5 volume per cent CO_2 if the sporophores had reached a certain stage when treatment was started, but even in this range elongation of the stipe occurred. Normal sporophores developed only when the CO_2 concentration was less than 0.2 per cent. There seems to exist a direct relationship between the cap : stipe weight ratio and the CO_2 content of the air surrounding the sporophores.
4. If culture boxes were aerated with air artificially enriched to 0.5 and 1.0 volume per cent CO_2, no sporophores developed. The mycelium grew through the casing and spread over its surface as in unventilated growing rooms or culture flasks.
5. The following theory is advanced concerning the function of the casing soil and the cause of fructification of the mushroom: The object of the casing soil is to create a CO_2 gradient from the air in the compost to the air above it, and fructification takes place in the region of this CO_2 partial pressure gradient.

ACKNOWLEDGEMENT

I wish to express my sincere gratitude to Professor **Dr. Riethus** for giving me the theme of this work. To the Senator für Wirtschaft und Kredit I am very much indebted for granting the funds from Berlin's ERP-means.

The very valuable stimulus and support given me by the Mushroom Growers' Association of Great Britain and Northern Ireland, especially by **Mr. F. C. Atkins** must be mentioned here; furthermore the most

valuable stimulus from **Dr. J. W. Sinden,** Gossau/Zürich, Switzerland.

To **Mr. Mende** I wish to express my sincere appreciation for giving me facilities to make a part of the experiments on his mushroom farm. And last but not least I have to thank **Miss M. E. Drath** for her excellent assistance in making the drawings and reading the original manuscript and **Dr. R. L. Edwards** for preparing the English manuscript.

This completes the series of articles by Dr. Tschierpe and the complete work, with full references, is to be published by the MGA in booklet form. Full details will be announced later.

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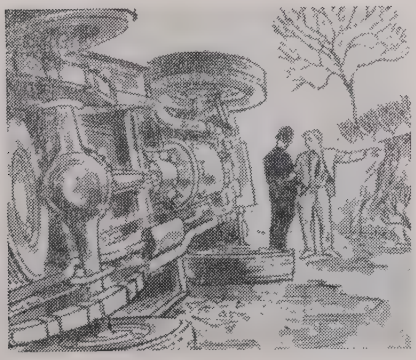

Water from a field drain, which had been allowed to become blocked, froze on the road and caused a serious accident.

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HEAD OFICE; STRATFORD-ON-AVON

EXECUTIVE COMMITTEE ELECTIONS, 1961

In accordance with decision taken at the 1957 Annual General Meeting, voting for the five vacancies on the Executive Committee this year will be by post. Last year this method of election proved quite satisfactory in that the number of members voting considerably exceeded the number of votes cast at A.G.Ms.

The elections this year concern two General Seats and three Area Seats, the Areas being B (Essex, Herts., Suffolk, Cambs., and Norfolk), C (Bucks., Beds., Oxon, Northants, Warwicks, Lincs., Notts., Leics., Derby, Rutland, Staffs., and Hunts.) and F (Glos., Wilts, Hants, Dorset, Somerset, Devon, Cornwall and Berks). **One representative is required from each area and only Grower Members in the areas concerned may vote, nominate or be nominated.** Members should ascertain, if possible, if the grower nominated is willing to stand. Members will be individually notified of the procedure to be adopted and this information will be circularised to those concerned on or before 27th January.

General Seats. Nominations for the two vacant seats **must be received by the MGA Secretary not later than 24th February,** and on the special forms to be provided.

The five retiring members this year are:—**Mr. E. G. Gook,** Kent (General Seat) and **Mr. Fred. C. Atkins** of Northants (Area C) both of whom have served for six consecutive years and are not eligible for re-election this year, and **Mr. Raymond Thompson** (General Seat) and the present Vice-Chairman of the MGA, **Mr. Graham Griffiths** (Area F) who offer themselves for re-election. **Mr. R. H. Pinkerton** who represented Area B resigned from the Committee.

The complete Membership List appeared in the December, 1960, MGA Bulletin (No. 132). Members listed in italics are not eligible for Executive Committee service. Present members of the Executive Committee are listed above the Editorial in this issue. **Mr. F. L. Filmer,** as Honorary Treasurer, has a permanent seat on the Executive.

Continued on Page 40

SMALL ADVERTISEMENTS

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CORRESPONDENCE

Your editorial in the December issue of the Bulletin leaves me completely staggered. If Mr. Patterson can get up and utter such nonsense that is his affair, but I am rather surprised that you should see fit to repeat it in the Bulletin when you, having been a farmer in Essex, know full well that every year, including this year, there is more straw burnt in the Eastern Counties than all the mushroom growers in this country will ever need and it is burnt because the normal price obtainable is not sufficient to make it worthwhile getting.

Two years ago at Bournemouth I made a little speech and warned growers that straw would most likely be in short supply because of the very wet weather. One grower replied that if they paid enough for it the farmers would find it. He was right then, he still is, and he always will be, so why waste good reading matter on such tripe as you have repeated.

As for talking about using hay, every sensible farmer knows that the surest way to lose money is to make hay and in any case, in any year, no matter what the conditions, hay is almost invariably double the price of best wheat straw. And then to talk about drying hay—this would put the cost somewhere in the region of £30 per ton and if growers can afford that we in the manure business have been underestimating their capabilities of paying for manure.

I dare not make any comment on the suggestion of using maize, except that if I delivered a load of manure from horses bedded on maize, the grower would think I had gone mad.

Apart from all this, you and I and Mr. Patterson will all be dead long before horse manure is in such short supply that there will not be enough to go round.

I think you ought to publish this because I think the subject matter in your editorial is a complete insult to everyone concerned in the mushroom-growing industry.

D. Griffiths (Stable Manures Ltd.)

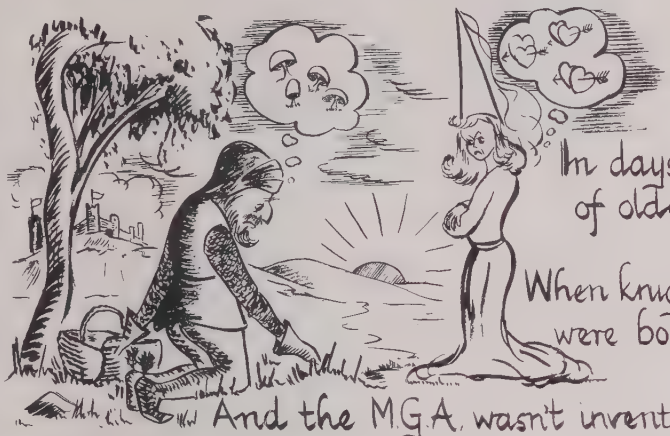
Editor's Note: Mr. Giffiths writes of present day conditions. The Editorial in question was endeavouring to look years ahead, farther maybe than the " open " or " we'll all be dead " stage to which Mr. Griffiths refers.

WHAT! NO PINHEADS?

The disappearance from the scene of Mr. Stanley Middlebrook's controversial " Pinheads " is only temporary. Says " S.M. "—" Give me a break if only a short one." He'll be back, never fear.

WESTON CONFERENCE

The first four papers given at the Weston-Super-Mare conference, with questions and answers, will be published in our next issue.



And the M.G.A. wasn't invented,

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And went home discontented.

But nowadays, with modern ways,

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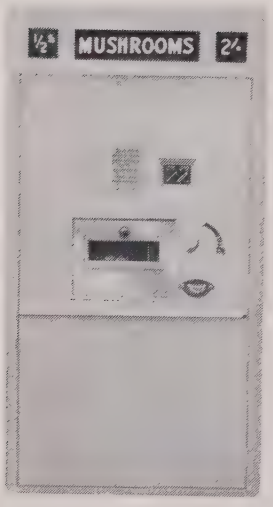
And fondly gaze on well filled trays

Results of well planned growing!

PETER DOOLE



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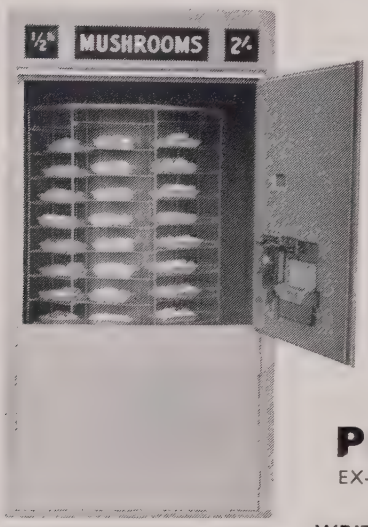

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